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ANALYSIS OF BIOLOGICAL SIGNALS USING WAVELET COEFFICIENTS FOR FINDING THE CARDIAC DISEASES & THEIR SEVERITY

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ABSTRACT

Our paper deals with feature extraction of Bio Medical signals using the continuous wavelet transform CWT and corresponding coefficients. We analyze the signal features, in various points of time and at different localization levels with multiple scales of the cwt.

In this paper we have analyzed the digital data collected using the electrocardiogram for finding the heart disease considering data sets of twenty different disease cases using mat lab.

Firstly we have filtered the ecg data for hum noise and muscle noise, using a series of filters and applied the zero cross algorithm for finding the no of zero crossings and the heart rate of each disease case.

We have applied wavelet transform and found the wavelet 3D plot which is the representation of the wavelet coefficients, which helps for estimating the cardiac disease from the wavelet 3D plot of the patient's electrocardiogram.

KEYWORDS: ECG, Wavelet, Feature Extraction, Hum Noise

INTRODUCTION

Now a days Electrocardiography is very important in medical field for diagnosis of heart diseases. The ECG signal contains an important amount of information that can be exploited in different manners. The ECG signal is analyzed to identify the anatomic and physiologic issues of the cardiac system. In this paper a new method is proposed to analyze the ECG signal using MATLAB.

In order to analyze the data of various fields like Signal and Image Processing, Medicine, SONAR, Radar etc., wavelet analysis is used. For identifying the tile threatening electrocardiography (ECG) arrhythmias Time-frequency wavelet theory is widely used.

They are usually presented in mathematical formulae, but can actually be understood in terms of simple comparisons with your data.

The analysis of ECG signal is very important to identify the abnormal beats to determine the heart beat rate, Tachycardia, Bradycardia etc.

ECG signal analysis provides some basic features like amplitudes and intervals which help in automatic analysis. These features are characterized by wave peaks and time durations which contains lot of medical information.

It is very essential to develop precise and faster techniques for automatic feature extraction of ECG signals.

It is very difficult to develop an algorithm for the detection of the P wave, QRS complex and T wave components of an ECG signal because of its time-varying nature consisting of noise and subjected to physiological conditions.

ABOUT THE ECG SIGNAL

An ECG signal is a graphical representation of direction and magnitude of electrical activities that are caused by depolarization and repolarization of the atria and ventricles. The ECG signal consists of the cycles of P-QRS-T components.

The Electrocardiograph is very useful term in the medical analysis of the patient's condition and reveals the present and future estimations of the heart diseases which help the doctors to take required steps for curing the heart problems. A normal ECG signal consists of the P-QRS-T. The QRS part of the ECG signal is useful in estimating the heart rate of the person in most of the cases. The two basic diseases or defects found in the heart function are APC and PVC. APC is Atria Premature Contraction and PVC is Premature Ventricular Contraction.

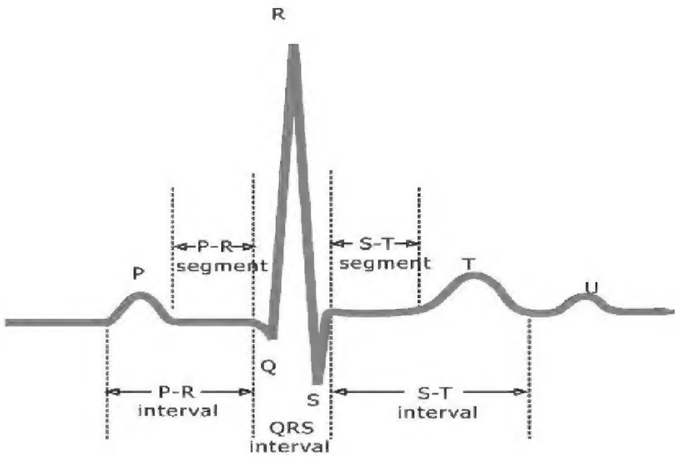

Figure 1: A Typical ECG Signal

The QRS complex and the R to R interval are used to find the Arrhythmic beats and some famous algorithms are used to detect the QRS complexes using an algorithmic approach. An ECG is the combination of (P wave + QRS complex + T wave) and in general QRS complex is considerably larger than the P wave.

THE CONTINUOUS WAVELET TRANSFORM (CWT)

The wavelet transform used to represent real-life non stationary signals with high efficiency. Because of its multi-resolution representation capability, wavelet transform is becoming an alternative to the time-frequency representation techniques such as discrete Fourier transform and discrete cosine transform. It has been used effectively in various applications such as transient signal analysis, numerical analysis, computer vision, image processing, audio and video etc.

THE WAVELET 3D PLOT AND OBSERVATIONS

In "MAT LAB" we use the function "cwt" and apply the wavelet using "morlet" mother wavelet. We store the digital data in a variable "data".

cwt (data,1:1:10,'morl','3Dplot');

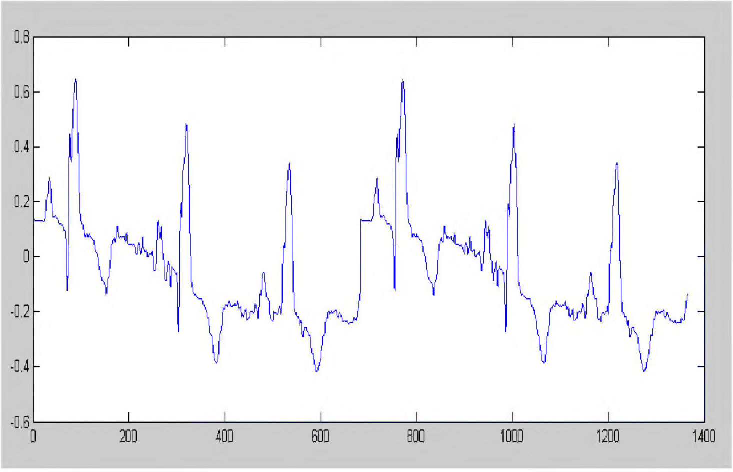

Figure 2: Sample ECG Signal from MIT Database for the Congestive Heart Failure Case

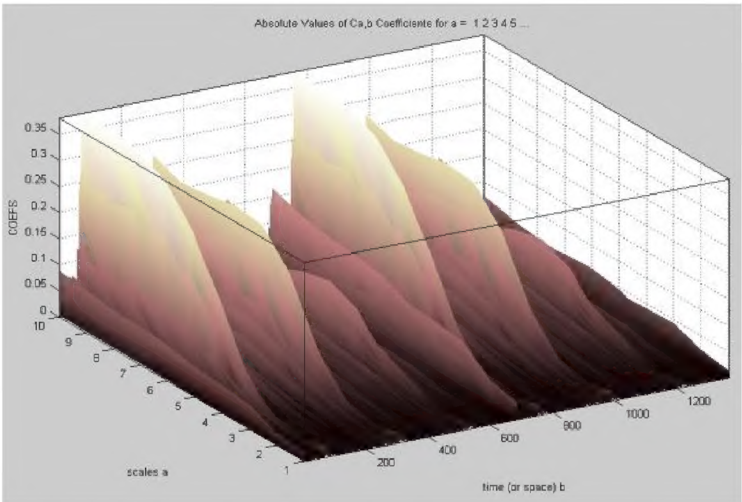

Figure 3: Wavelet 3d Plot for ECG Signal from MIT Database

- The larger is the wavelet scale the more we can localize in to the signal and more is the computational complexity.
- The wavelet 3Dplot in the larger scale values resembles the signal for which the wavelet is found.
- The peak values in the base signal correspond to negative valued wavelet coefficients and vice versa.
- The wavelet generated for the initial scales is proportional to the signal taken or the ECG signal.
- The more is the scale range the computational complexity of the methodology to find the 3D plot increases to the respective extent.
- Wavelet generated with morlet mother wavelet looks better for finding even the minute changes of the signal in time axis.
- The wavelet for increasing scale number is faded down compared to the given ECG signal for each increasing scale value.
- Instead of visual observations comparison of ECG analysis using the wavelet coefficients yields better and accurate results.

IMPLEMENTATION STAGES

- Collection of Bio Medical data.
- Collection of Reference data.
- Conversion in to digital values.
- Applying CWT and gathering the coefficients.
- Manual & Algorithmic approach for finding the disease.

ZERO CROSS ALGORITHM

Heart Rate detection using notch filtering and band pass filtering with the use of 60-Hz Hum Eliminator and Heart Rate

Detection Using ECG.

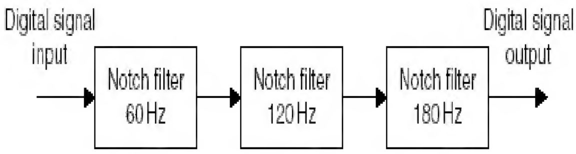

Figure 4: Hum Noise Filters for 60 Hz, 120 Hz and 180Hz

In this report we have explained the implementations on ECG data sets collected at 250Hz sampling rate. Hum noise created by poor power supplies, transformers, or electromagnetic interference sourced by a main power supply is characterized by a frequency of 60 Hz and its harmonics. If this noise interferes with a desired audio or biomedical signal (e.g., in electrocardiography [ECG]), the desired signal could be corrupted and it is no more useful. So the signal enhancement is applied to the ECG signal as shown in figure 5. In this fundamental frequency of hum noise signal and its harmonic up to third order (i.e., 60 Hz, 120 Hz and 180 Hz) are eliminated by using notch filters.

Filter Designing

Notch filter coefficients were designed using pole zero placement method for 60,120 and 180 Hz components removal. Band pass filter coefficients for removing muscle noise between 0.25Hz to 40Hz is done using bilinear transformation method. A major source of frequent interference is the electric-power system due to electric-field coupling between the power lines and the electrocardiograph or patient, which is the cause of the electrical field surrounding mains power lines. Another cause is magnetic induction in the power line, whereby current in the power line generates a magnetic field around the line. Sometimes, the harmonics of 60-Hz hum exist due to nonlinear sensor and signal amplifier effects.

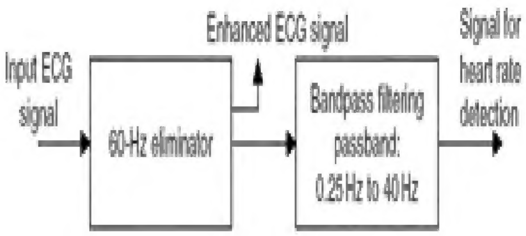

Figure 5: ECG Signal Enhancement System

Analysis Estimated Results

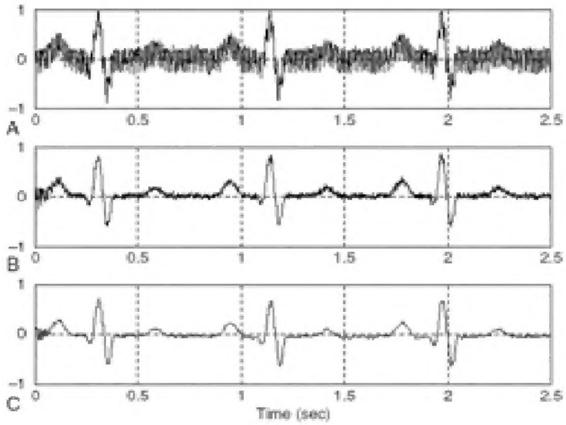

Figure 6: Results of ECG Signal Processing Prior to Implementation of Algorithm

The first figure shows the ECG signal with Hum noise, the second one is the signal removed or filtered from the 60,120,180 Hz hum noise, the third one is the ECG signal filtered from the muscle noise.

Algorithm

The ECG data after filtered with 3 stages of notch filters and finally sent through band pass filter is considered for the heart rate calculation using the zero cross algorithm.

The algorithm has some prerequisites to be assigned with, according to the size and sampling frequency of the considered data.

After detecting the total number of zero crossings, the number of the peaks will be half the number of the zero crossings. The heart rate in terms of pulses per minute can be determined by

$$\text{Heart rate} = \frac{60}{\left(\frac{\text{Number of enhanced ECG data}}{f_s}\right)} \times \left(\frac{\text{zero-crossing number}}{2}\right).$$

Equation 1: Calculation of heart rate from the no of zero crossings, Where *fs* = Sampling frequency

Results

All results are with reference to data sets of different sampling frequency with Zero cross algorithm applied individually.

Table 1: Heart Rate in Beats per Minute Calculated Using the Zero Cross Algorithm for Various Disease Cases

Considered Case of Heart Disease	Sampling Frequency	No of Zero Crossings	Heart Rate in Beats/Min
Congestive heart failure database	250	12	60
Long term ST database	250	14	70
Very subtle premature ventricular contraction	250	20	100
Maligant Ventricular ectopy database	250	28	56
Noramal sinus rythym database	165	38	125
AANSI AMI database	721	4	56
AF termination database	129	28	72

Table 1: Contd.,

APNEA database	101	32	64
Long term ECG database	129	26	67
Sudden cardiac death hotler database	361	8	48
Poly somographic database	251	14	69
Postal ictal heart rate oscillations in partial epilepsy	201	18	72
Stress recognition in automobile drivers	16	16	46
AHA database	251	16	80
Congestive heart failure database	251	20	100
Intra cardiac atrial fibrillation	1001	4	80
MGH_MF Waveform database	361	6	86
CU ventricular tachyarrhythimia database	251	12	86
Wave alternas challenge database	501	6	60
PAF prediction challenge database	129	34	87

CONCLUSIONS

Long Term ST Database with Manually corrected beat annotations with sampling frequency of 250 Hz (row 2 in table 1).

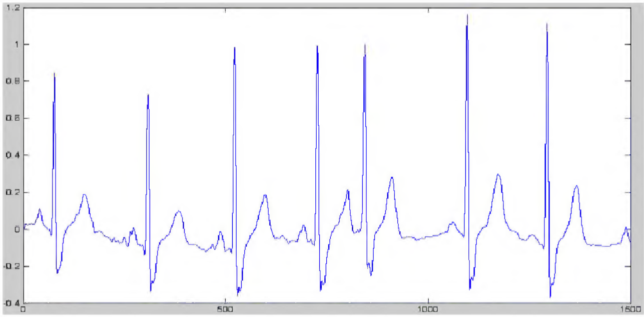

Figure 7: Actual ECG signal

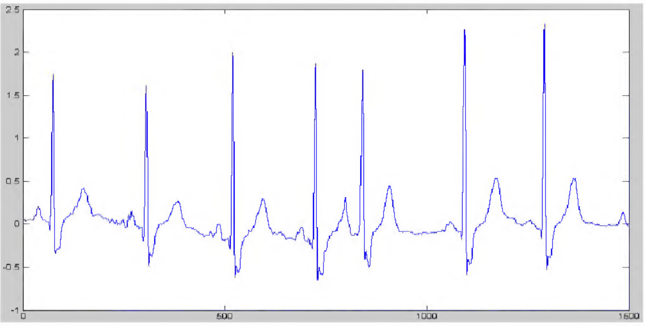

Figure 8: ECG Signal Filtered for Hum Noise and Muscle Noise

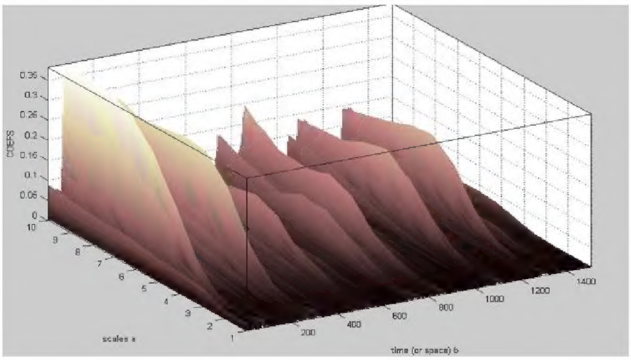

Figure 9: Wavelet 3D Plot for the above ECG

Output of the Algorithm

- No of Zero Crossings = 14.
- Heart Rate in (Beats/Min) = 70.

We conclude that the above implementation helps for the detailed analysis of the biomedical data for finding the diseases and severity.

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